

What is claimed is:

1. A method of preparing a catalyst material, comprising the steps of:  
providing a substrate component having a surface;  
producing on said surface of said substrate component a second component having  
metallic crystalline particles and a structure lacking crystallinity; and  
removing selectively from said surface of said substrate component at least some  
of said metallic crystalline particles, leaving associated with said substrate  
component at least a portion of said structure lacking crystallinity;  
whereby said remaining structure lacking crystallinity associated with said  
substrate component exhibits catalytic activity.
2. The method of claim 1, wherein said catalytic activity of said remaining structure  
lacking crystallinity and said substrate component is substantially equal to a catalytic  
activity exhibited by said catalyst material prior to said selective removal of  
crystalline particles.
3. The method of claim 1, wherein the step of providing said substrate component  
comprises forming said substrate by a gelation/coprecipitation process followed by  
calcining.
4. The method of claim 1, wherein the step of producing on said surface of said  
substrate component a metallic component comprises applying said metallic  
component by a process selected from precipitation, co-precipitation, gelation,  
evaporation, a deposition-precipitation process, an impregnation process, adsorption

of molecules followed by decomposition, ion implantation, chemical vapor deposition, and physical vapor deposition.

5. The method of claim 1, wherein said substrate component comprises a microcrystalline substance.
6. The method of claim 1, wherein said substrate component is sintered at a temperature of approximately 400 degrees Centigrade.
7. The method of claim 1, wherein said substrate component comprises a selected one of a rare-earth-, an alkaline earth-, a Sc- or a Y-doped cerium oxide.
8. The method of claim 7, wherein said rare-earth is lanthanum.
9. The method of claim 1, wherein said metallic component comprises an element selected from the group consisting of Au, Pt, Cu, Rh, Pd, Ag, Fe, Mn, Ni, Co, Ru, and Ir.
10. The method of claim 1, wherein said removal step comprises a process selected from the group consisting of leaching, etching, and dissolving.
11. The method of claim 1, wherein said removal step comprises leaching with a solution of NaCN.

12. The method of claim 11, wherein said removal step comprises leaching with an aqueous solution of 2 percent NaCN having a pH of at least 11.
13. The method of claim 1, wherein said removal step removes at least 10% of said metallic component.
14. The method of claim 1, wherein said removal step removes at least 25% of said metallic component.
15. The method of claim 1, wherein said removal step removes at least 50% of said metallic component.
16. The method of claim 1, wherein said removal step removes at least 90% of said metallic component.
17. The method of claim 1, wherein said catalytic activity is exhibited in the performance of a water gas shift reaction.
18. The method of claim 1, wherein said substrate comprises a metal oxide.
19. The method of claim 1, wherein said substrate comprises a selected one of a zeolite, a carbide, a nitride, a sulfate, and a sulfide.
20. The method of claim 1, wherein said substrate comprises a crystalline defect solid

that provides oxygen to a reaction.

21. A catalyst material prepared according to the method of claim 1.
22. The catalyst material of claim 21, wherein said metal is selected from the group consisting of Au, Pt, Cu, Rh, Pd, Ag, Fe, Mn, Ni, Co, Ru, and Ir.
23. The catalyst material of claim 21, wherein said substrate component comprises a microcrystalline substance.
24. The catalyst material of claim 21, wherein said substrate component comprises an oxide.
25. The catalyst material of claim 21, wherein said substrate component comprises a selected one of a zeolite, a carbide, a nitride, a sulfate, and a sulfide.
26. The catalyst material of claim 21, wherein said metallic component is Au and said substrate component is lanthanum-doped cerium oxide.
27. The catalyst material of claim 26, wherein the Au has a concentration in the range of one atomic percent to one one-hundredth of an atomic percent, wherein the atomic percentage is computed according to the expression
$$\left[ \frac{100 \times \text{grams Au} / (\text{atomic mass of Au})}{\text{grams Au} / (\text{atomic mass of Au}) + \text{grams Ce} / (\text{atomic mass of Ce}) + \text{grams La} / (\text{atomic mass of La})} \right],$$
based on a chemical

composition of the catalytic material.

28. The catalyst material of claim 26, wherein the Au has a concentration in the range of one-half of an atomic percent to one-tenth of an atomic percent, wherein the atomic percentage is computed according to the expression
- $$\frac{[100 \times \text{grams Au}/(\text{atomic mass of Au})]}{[\text{grams Au}/(\text{atomic mass of Au}) + \text{grams Ce}/(\text{atomic mass of Ce}) + \text{grams La}/(\text{atomic mass of La})]},$$
- based on a chemical composition of the catalytic material.
29. The catalyst material of claim 26, wherein the Au has a concentration in the range of 0.44 atomic percent to 0.23 atomic percent, wherein the atomic percentage is computed according to the expression
- $$\frac{[100 \times \text{grams Au}/(\text{atomic mass of Au})]}{[\text{grams Au}/(\text{atomic mass of Au}) + \text{grams Ce}/(\text{atomic mass of Ce}) + \text{grams La}/(\text{atomic mass of La})]},$$
- based on a chemical composition of the catalytic material.
30. The catalyst material of claim 21, wherein said catalyst material is a catalyst for awater shift reaction.
31. The catalyst material of claim 21, wherein said catalyst material is a catalyst for a steam reforming reaction.
32. A chemical apparatus comprising a catalyst material according to claim 21.
33. The apparatus of claim 32, wherein said chemical apparatus is a chemical reactor.

34. The apparatus of claim 32, wherein said chemical apparatus is an analytical instrument.
35. A method of performing a chemical reaction, comprising the steps of:  
providing a catalytically effective amount of a catalyst material, said catalyst material comprising:  
a substrate component having a surface; and  
adjacent said surface of said substrate, a metallic residue of a metal deposit, said metal deposit comprising a portion having a structure lacking crystallinity and a portion having crystalline particles, said metallic residue comprising at least some of said structure lacking crystallinity and being the remnant of said metal deposit from which at least some of said crystalline particles having dimensions greater than a nanometer have been selectively removed; and  
exposing said catalyst material to a selected chemical substance under predetermined conditions of temperature and pressure;  
whereby said selected chemical substance undergoes a catalyzed chemical reaction to produce a product.
36. The method of claim 35, wherein said catalyst material comprises a metal selected from the group consisting of Au, Pt, Cu, Rh, Pd, Ag, Ni, Co, and Ir.
37. A product prepared according to the method of claim 35.

38. A product according to claim 37, wherein said product is hydrogen, and said chemical reaction is a water shift reaction
39. A product according to claim 37, wherein said product is hydrogen, and said chemical reaction is a methanol steam reforming reaction.
40. A composition of matter, comprising, in combination:
- a substrate component having a surface, said substrate comprising a selected one of an oxide, a carbide, a nitride, and a sulfide; and
  - a residue of a metal deposit adjacent said surface, said metal deposit comprising a selected one of Au, Pt, Cu, Rh, Pd, Ag, Ni, Co, and Ir, said residue comprising a non-crystalline metallic substance that remains associated with selective removal of at least some metallic crystalline particles having dimensions greater than a nanometer from said metal deposit;
- whereby said combination comprises a composition of matter having catalytic behavior greater than that of said substrate alone.
41. A catalyst material having a substrate and a metallic substance adjacent thereto, comprising:
- a purified form of said catalyst material comprising a non-crystalline metallic substance, said purified catalyst material obtained by selective removal of at least some crystalline particles of said metallic substance;
- whereby said catalyst material is freed of metallic crystalline particles having

substantially no catalytic activity, while retaining substantially all of the catalytic activity of said catalyst material.

42. The catalyst material according to claim 41, wherein said catalytic activity is measured with respect to a rate of reaction per gram of the catalyst material.
43. The catalyst material according to claim 41, wherein said catalytic activity is measured with respect to a rate of reaction per unit mass or per unit surface area of the catalyst material..
44. An improved catalyst material having a substrate and adjacent thereto a metallic residue of a metal deposit, said metal deposit comprising a portion having a structure lacking crystallinity and a portion having crystalline particles, said metallic residue comprising at least some of said structure lacking crystallinity and being the remnant of said metal deposit from which at least some of said crystalline particles have been removed, wherein the improvement comprises:
  - reduction of a metallic content of said improved catalyst material by said selective removal of at least some crystalline particles of said metallic substance, thereby reducing the amount of metal contained in said catalyst material while retaining substantially all of a catalytic activity exhibited by said catalyst material prior to said selective removal of said crystalline particles.